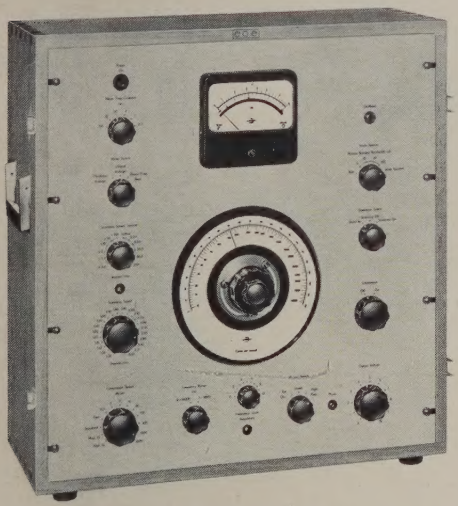
1040

INSTRUCTIONS AND APPLICATIONS

N670

Sine-Random Generator Type 1040



Designed for use in an integrated vibration test system in conjunction with the Vibration Meter Type 2501 or independently as a sinusoidal, narrow band random or wide band random signal generator. The frequency of the sinusoidal output and the centre frequency of the narrow band random output signal is tuneable manually, or automatically by a built-in motor. The Generator contains a compressor circuit which is fed from the Vibration Meter, making it possible to maintain the vibration level on the shaker table constant during a frequency sweep. Frequency range 5—10000 Hz (c/s).

Accelerometers
Acoustic Standing Wave Apparatus
Artificial Ears
Artificial Voices
Audio Frequency Response Tracers
Audio Frequency Spectrometers
Audio Frequency Vacuum-Tube Voltmeters
Automatic A. F. Response and Spectrum Recorders
Automatic Vibration-Exciter Control Generators
Band-Pass Filter Sets
Beat Frequency Oscillators
Complex Modulus Apparatus
Condenser Microphones
Deviation Bridges
Distortion Measuring Bridges
Frequency Analyzers
Frequency Measuring Bridges
Hearing Aid Test Apparatus
Heterodyne Voltmeters
Level Recorders
Megohmmeters
Microphone Accessories
Microphone Amplifiers
Microphone Calibration Apparatus
Mobile Laboratories
Noise Generators
Noise Limit Indicators
Pistonphones
Polar Diagram Recorders
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Surface Roughness Meters
Variable Frequency Rejection Filters
VHF-Converters
Vibration Pick-ups
Vibration Pick-up Preamplifiers
Wide Range Vacuum Tube Voltmeters

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Sine-Random Generator

Type 1040

APRIL 1964

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Introduction

The Sine-Random Generator Type 1040 is designed to be used in integrated vibration test systems for controlling the shaker table movement. The generator can supply sine-wave signals, or narrow band noise signals (with various bandwidths) as well as a wide-band noise signal. It has a frequency range of 10 c/s—10 kc/s and additionally a range 5 c/s—9,995 kc/s. A regulation (compressor) arrangement designed to work in a closed servo loop offers programmed and selectable regulation speeds.

The compressor makes it possible to maintain, for example, constant acceleration, velocity or displacement level of the shaker table movement, in both sine-wave and narrow noise band conditions.

The generator incorporates a reversible motor drive, for continuously scanning the frequency scale. Several scanning speeds can be chosen and a built-in vacuum tube voltmeter with selectable integration times measures the r.m.s. value of the output signal.

The Sine-Random generator is intended to be used together with the Vibration Meter Type 2501 on which the various vibration levels can be read and via which the regulation signal for the compressor arrangement is supplied. Several of the Sine-Random Generator's functions can be remotely controlled. In cases where two or more vibration systems have to be operated in parallel, the Generators can be wired up in a "master-slave" arrangement.

1. Description

The basic principle of operation of the Sine-Random Generator is illustrated in the block diagram Fig. 1.1.

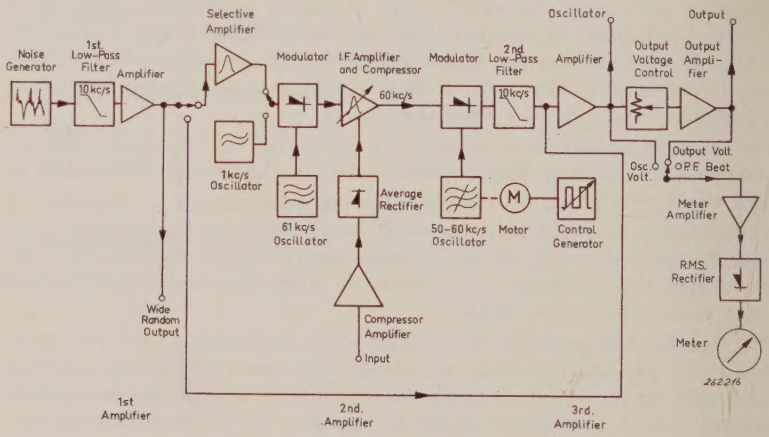

Fig. 1.1. Block diagram of Sine-Random Generator.

Output Spectra.

Narrow Band Noise Condition. A noise generator supplies a wide band noise signal with constant spectrum density (white noise) and Gaussion voltage distribution, via a low-pass filter with a limiting frequency of 10 kc/s to an amplifier. In this amplifier the signal is filtered in a selective network having a fixed center frequency f_0 of 1000 c/s. The 3 dB bandwidth of the selective amplifier can be chosen in four steps, viz. 3, 10, 30 and 100 c/s Fig. 1.2.

The selected noise band is then applied to a balanced modulator, where it is modulated by a carrier frequency of 61 kc/s obtained from a fixed oscillator. The lower sideband (60 kc/s) of the modulated signal is separated in an i.f. amplifier. This amplifier can simultaneously act as a regulation amplifier, as described later. After the lower side-band has been selected the

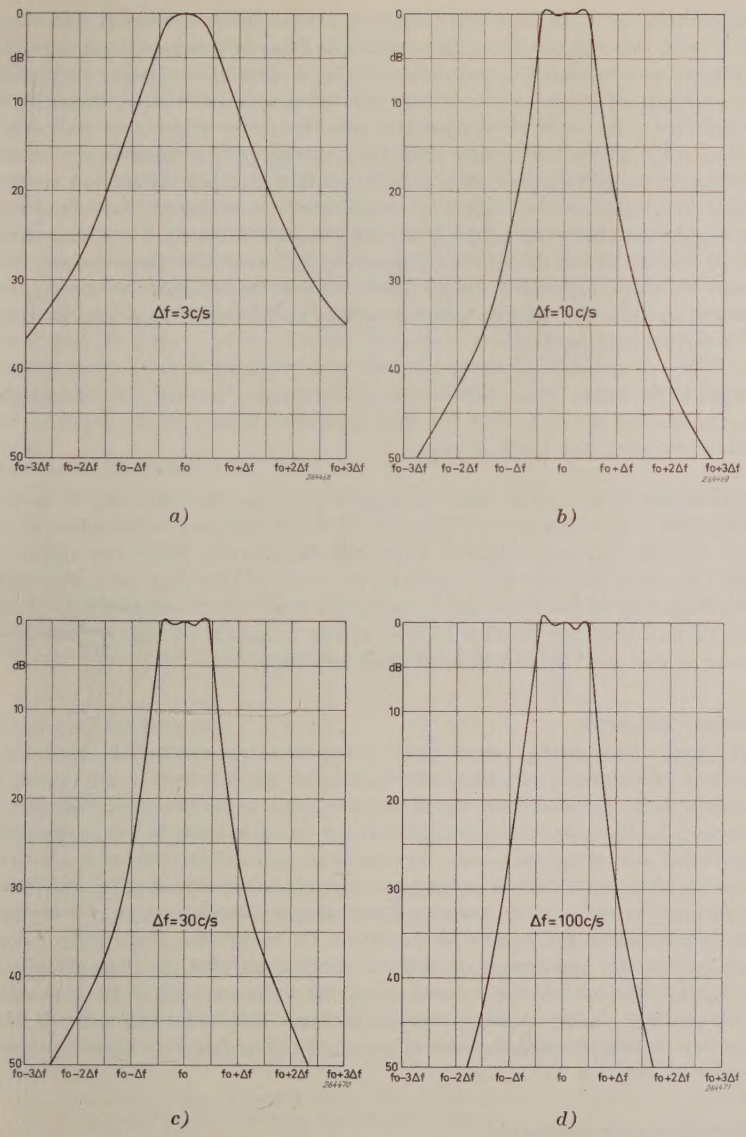

Fig. 1.2. Typical narrow band noise spectra available from the Generator.

signal is again modulated, this time by a carrier the frequency of which can be varied from 50—60 kc/s. The lower side-band of the modulated signal is selected by a second low-pass filter having a limiting frequency of 12 kc/s whereby it appears as a noise band, the bandwidth and center frequency of which are determined by the selective amplifier stage and the variable oscillator, respectively. The center frequency can be varied continuously in the frequency range 10 c/s—10 kc/s and the actual frequency setting can be read on a circular logarithmic scale. A second range, 5—9,995 c/s, is obtained by changing the frequency of the fixed (61 kc/s) oscillator by 5 c/s. The signal from the 2nd Low Pass Filter passes an L.F. amplifier stage before it is applied to an adjustable output level control immediately preceeding the output amplifier. A cathode follower is used in the output amplifier ensuring a low output impedance.

Wide Band Noise. Wide band noise in the range 5 c/s—10 kc/s is supplied by connecting the output of the first amplifier directly to the input of the third amplifier. See block diagram.

Sine-Wave. A sine-wave signal is supplied by the Sine-Random Generator when the 1 kc/s oscillator, shown on the block diagram, is switched in, in place of the selective amplifier stage and the previous links. The signal on the output of the Sine-Random Generator will in this case be a sine-wave the frequency of which can be chosen in the range 10 c/s—10 kc/s or 5—9,995 c/s by means of the variable oscillator. The frequency is read on the same scale as that used for the Narrow Band condition.

Output Voltmeter.
The r.m.s. level of the output signal, noise or sine-wave, can be read on a built-in indicating meter. The indicating meter section contains an amplifier, a full wave (quasi) r.m.s. signal rectifier and a moving coil instrument. Various time constants can be selected for the signal rectifier thus ensuring sufficient averaging time even for the very narrow noise band 3 c/s. The moving coil instrument is fully protected against overload. The indicating meter can be switched to measure the oscillator output level i.e. the level at the point before the output level control. By measuring this voltage when setting up the compressor it can be ascertained that the compressor is properly adjusted i.e. that it works over the optimum part of its regulation characteristic in the required frequency range. The indicating meter is also utilized during frequency calibration of the Sine-Random Generator. See under "Frequency Calibration".

Compressor Arrangement.
The output signal level from the Sine-Random Generator can be automatically regulated by means of a built-in regulation (compressor) arrangement. By

utilizing this arrangement in a closed servo loop levels, such as acceleration, velocity etc., can automatically be kept constant on the shaker table. The compressor arrangement includes a compressor amplifier, an average type full wave signal rectifier and a regulation amplifier. This regulation amplifier is formed by two of the stages in the i.f. amplifier, which are designed as variable-μ amplifiers. The gain of the two stages is controlled by a DC voltage obtained from the regulation signal applied to the compressor input terminal. An average type rectifier is used for signal rectification to ensure equal regulation time constants for increasing and decreasing signal levels.*) The regulation speed (regulation time constants) can be selected manually in nine steps, covering the range 0.3 to 3,000 dB/sec., or can be adjusted automatically as a function of frequency according to four different programmes, refer to part "Control Knobs, Terminals etc.". When the compressor arrangement is switched into operation the gain of the 2nd amplifier is simultaneously increased by approximately 10 dB.

Automatic Frequency Scan.

The frequency range can be continuously scanned with various speeds by a built-in synchronous motor which can be reversed electrically. A unijunction transistor oscillator supplies the power for the motor. By altering the frequency of the oscillator the motor speed can be changed in six coarse steps, covering the range 0.3 to 100 degrees/min. Within each of the six steps the speed can be fine adjusted in 22 steps. Using both controls provided, there are 132 possible scanning speeds from 0.3 to 300 degrees/min.**)

Frequency Calibration.

The Generator is frequency calibrated by checking two points on the frequency scale against a well defined frequency. The reference frequency is that of the mains supply which is compared first to the fundamental and then to the fifth harmonic of the Generator signal. The fifth harmonic of the Generator signal is obtained by feeding the Generator output signal to the indicating meter via a network causing heavy non-linear distortion. By also applying a part of the mains supply voltage to the indicating meter, a beat between the two signals will result. When the Generator is set to the fundamental of the mains supply frequency a zero beat is obtained for correct calibration. The fine calibration can be made in a similar way at one fifth of the mains frequency. Any necessary adjustment of the Generator frequency is made by a separate control, changing the frequency of the variable oscillator.

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*) See also Brüel & Kjær Technical Review No. 4, 1962, P. E. Møller Petersen, "Problems in Feed Back Control of Narrow Band Random Noise".

**) Additionally there are six other scanning speeds suitable for achieving synchronism with the frequency-calibrated-paper transport on the Brüel & Kjær Level Recorder Type 2305.

Remote Control.

Various functions of the Sine-Random Generator can be remotely controlled, they are:

1. Start and Stop of automatic frequency scan.*)
2. Changing frequency scan from forward to reverse and vice-versa.
3. Stand by, which is a condition of the Generator where the output voltage is suppressed by the compressor.

About the wiring for the various remote control facilities the operator is referred to part "Operation" in this book.

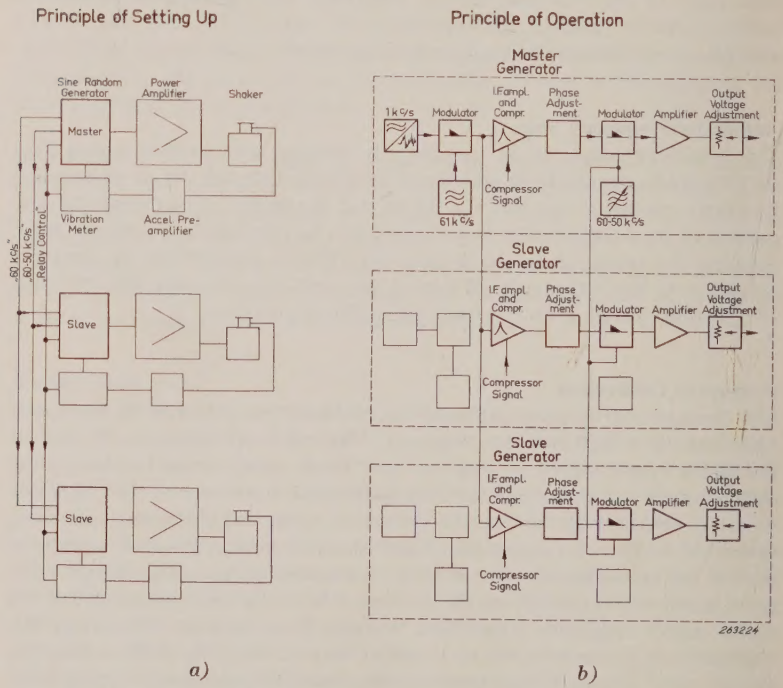


Fig. 1.3. "Master slave" arrangement of 3 Sine-Random Generators.

*) In case the Brüel & Kjær Level Recorder Type 2305 is used together with the Generator the start and stop of the Recorder paper drive can be synchronized with the remote start and stop of the frequency scan.

Parallel Operation of Generators.

Two or more complete vibration systems can be driven in parallel in a so-called "master-slave" arrangement, which means that one of the paralleled Sine-Random Generators, the "master", governs the others, Fig. 1.3a. The basic principle in the parallel arrangement is that the signals from both the fixed and the variable oscillator in the "master" are used not only for the "master" itself but for the "slaves" as well, Fig. 1.3b. This means that the shakers driven in this parallel arrangement are vibrating with the same frequency but have individual compressor systems. The phase difference in the movement of the different shaker tables can be adjusted on the individual Generators. Also the programmed compressor speed setting, working as a function of frequency, can be governed from the "master", so that the compressors of the "master" and the "slaves" regulate with equal speeds, but at individual vibration levels. Full details about the wiring and lining up is given in part "Operation" in this book.

2. Control Knobs, and Terminals

Front Panel (refer to Fig. 2.1).

POWER ON: To switch the power on and off for the complete apparatus. When switched on the indicating meter and frequency scales are illuminated.

METER TIME CONSTANT: For alteration of meter rectifier averaging time. The selectable values "0.3", "1", "3", "10", "30", and "100" sec. indicate the time it takes the meter pointer to fall, when disconnecting the signal, to 1/3 of the original deflection.

METER SWITCH: **"Oscillator Voltage".** The r.m.s. signal level at the point before OUTPUT VOLTAGE attenuator, i.e. at the front panel terminal OSCILLATOR, is read on the indicating meter. It is intended to be used during set-up of a test for checking the drive of the circuits preceeding this measuring point. Full indicating meter deflection indicates full r.m.s. drive of the circuits.

"Output Voltage". R.M.S. level of signal on socket OUTPUT (rear panel) is read. Full deflection indicates full r.m.s. drive of the output amplifier.

"Power Frequency Beat". In this position the complete Generator can be frequency calibrated against the mains supply frequency.

(Covers both FREQUENCY RANGE control positions).

SCANNING SPEED SELECTOR: **"× 0.3" "× 1" "× 3" "× 10" "× 30" and "× 100"** are factors by which the degrees/min. value indicated on the SCANNING SPEED control should be multiplied. The result gives the actual scanning speed of the frequency scale pointer in degrees/min. The six values on the right side of the control indicate the speeds available when the Brüel & Kjær Level Recorder Type 2305 is used in combination with the Sine-Random Generator. The correlation between the six different values and the paper

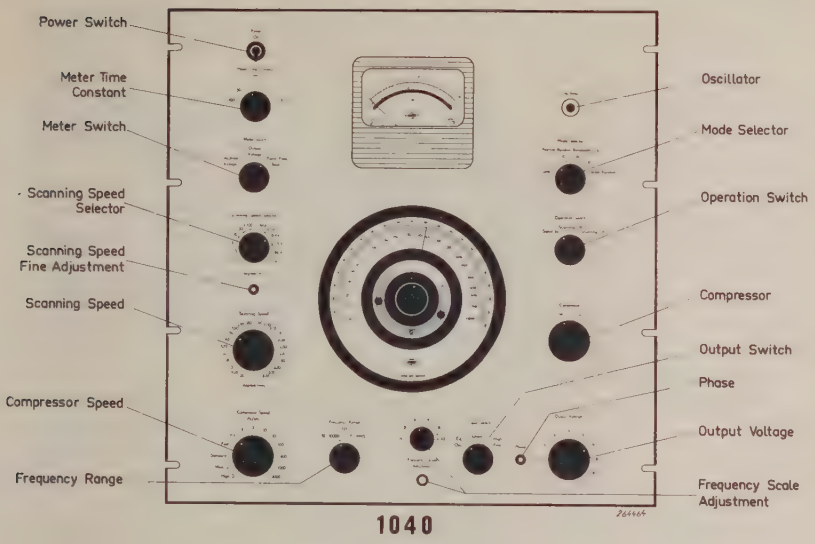


Fig. 2.1. Sine-Random Generator front panel.

speed setting on the Level Recorder is shown in the table below.

The motor supply frequency can be fine adjusted by the screwdriver control located below the SCANNING SPEED SELECTOR.

"Scanning Speed selector" position degrees/min	0.864	2.59	8.64	25.9	86.4	259
Level Recorder Paper Speed mm/sec	0.01	0.03	0.1	0.3	1	3
Pulse interval for Sine-Random Generator drivemotor. Milliseconds	50.00	16.67	5.000	55.54	16.66	5.554

NOTE: When set to one of the scanning speeds tabulated above, the SCANNING SPEED control below the SCANNING SPEED SELECTOR is automatically switched out of circuit.

The exact frequency (or pulse interval) of the motor power supply can be monitored on, for example, an electronic counter. The signal is available on the

rear of the Generator at the socket SWEEP CONTROL B between pin 3 and chassis.

SCANNING SPEED: For setting, in combination with SCANNING SPEED SELECTOR, the speed for the automatic frequency scanning device. To obtain the actual scanning speed the degrees/min. value indicated by SCANNING SPEED has to be multiplied with the factor indicated by the SCANNING SPEED SELECTOR. The SCANNING SPEED control is not in operation when the SCANNING SPEED SELECTOR is set to one of the six values printed to the right of the control knob.

FREQUENCY RANGE ADJUSTMENT: The frequency range which should be scanned by the internal motor can be preset by two finger screws. When the scale pointer reaches the preset points on the scale the motor reverses automatically

COMPRESSOR SPEED: For setting the regulation speed of the compressor arrangement. In operation only when the knob COMPRESSOR is set to position ON.
"0.3", "1", "3" ..... "3000" indicate fixed regulation speeds in dB/sec. which do not change as a function of frequency.
"High Q", "Med. Q", "Standard" and **"Fast"** refer to different programmed changes in regulation speed as a function of frequency. The speed is altered step-wise to the various values, and at the frequencies, given in the table below:

"Compressor Speed" position	Change-over frequency*) 30	100	300	1000 c/s	
"Fast"	30	100	300	1000	3000 dB/sec
"Standard"	10	30	100	300	1000 dB/sec
"Med. Q"	10	10	30	100	300 dB/sec
"High Q"	10	10	10	30	100 dB/sec

FREQUENCY RANGE: **"10—10000 c/s".** The frequency scale graduation is read directly.

*) In the frequency range 5—9995 c/s the change-over frequencies are 5 c/s lower than stated in the table.

"5—9995 c/s". To find the output frequency 5 c/s has to be subtracted from the frequency scale reading.

FREQUENCY SCALE ADJUSTMENT:

For frequency calibration of the Generator, changes the frequency of the variable oscillator. The screw-driver operated control is for coarse adjustment in case the range of the fine adjustment control is not sufficient.

OUTPUT SWITCH:

"Ext. Osc.". The fixed oscillator (61 kc/s) is disconnected so that no signal is present at the Generator output.
An external oscillator can then be connected to the OSCILLATOR terminal located on the front panel.

"Linear". The amplitude-frequency characteristic of the generator is flat, independent of frequency.

"High Pass". The lower part of the frequency range is attenuated by a high-pass filter. The limiting frequency is 15 c/s and the maximum slope is 6 dB/octave below this frequency.

PHASE:

In, for example, a "master slave" arrangement, the phase between the individual Generators output signals can be adjusted. The phase shifting range covered by the screw-driver operable control is approximately 150°.

OUTPUT VOLTAGE:

Continuously variable logarithmic potentiometer, located at the input of the output amplifier, i.e. immediately following the OSCILLATOR terminal.

FREQUENCY SCALE:

Inner scale, logarithmic. Scale pointer indication either the frequency of the output sine-wave or the centre frequency of the narrow band noise output signal.

DEGREE SCALE:

Outer scale, linear. For determining the scanning speed in degrees/min.

COMPRESSOR:

"Off". The regulation (compressor) arrangement is disconnected.

"On". The compressor arrangement is switched in circuit. Simultaneously, the gain of the i.f. amplifier

section is increased approximately 10 dB, ensuring a larger regulation range.

OPERATION SWITCH:

"Stand by". The output signal of the Generator is suppressed by the compressor circuit by more than 70 dB relative to full drive. The speed at which the signal is suppressed and rises again with COMPRESSOR set to OFF is in the order of:

Decay time (90—10 %), 150 m sec.

Rise time (10—90 %), 30 m sec.

When the COMPRESSOR is in "On" position, the rise time depends on the COMPRESSOR SPEED setting, i.e. a high speed gives a short rise time. The decay time, however, is independent of COMPRESSOR SPEED setting and has the value given above.

"Scanning Off". The automatic frequency scanning drive is stopped instantaneously.

"Scanning On". The automatic frequency scanning drive is started instantaneously.

MODE SELECTOR:

"Sine". At this position the Generator supplies a sine-wave signal at the output terminals OSCILLATOR and OUTPUT which are accessible at the front and rear panel respectively.

"Narrow Random". The figures "3", "10", "30" and "100" give the 3 dB bandwidth in c/s of the noise bands available at the terminals OSCILLATOR and OUTPUT. The shape of the noise bands are illustrated in Fig. 1.2.

"Wide Random". A noise signal with uniform spectrum density (white noise) in the frequency range 5 c/s — 10 kc/s and with Gaussian distribution is present at the terminals OSCILLATOR and OUTPUT. In this case the compressor arrangement will not operate.

OSCILLATOR:

Terminal parallel to the input of the OUTPUT VOLTAGE control potentiometer.

Indicating Meter:

Measures the r.m.s. signal level at the OSCILLATOR or OUTPUT terminals. Also used during frequency calibration of the complete Generator. The various functions are selected by the "Meter Switch".

Rear Panel (refer to Fig. 2.2).

Wide Random Output: Wide band noise (5 c/s — 10 kc/s) with an r.m.s. level of approximately 5 V.
Load impedance can be 25 kΩ or higher. Maximum capacitive load 3 nF.

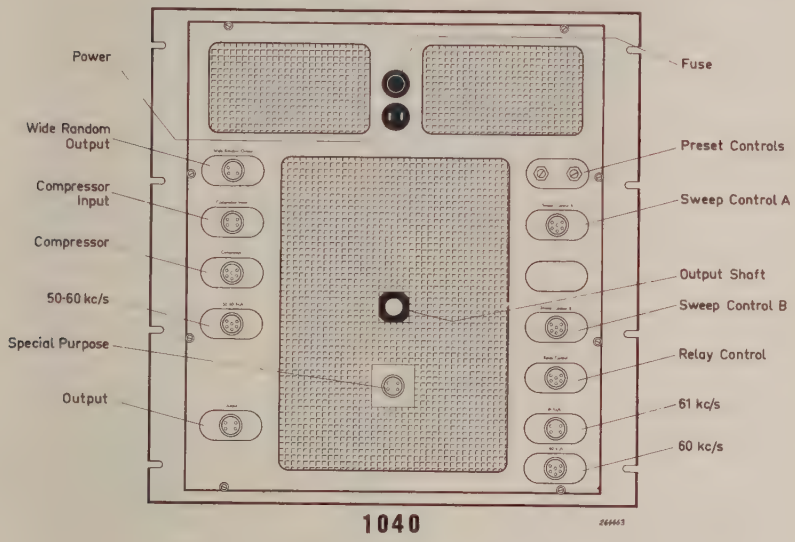
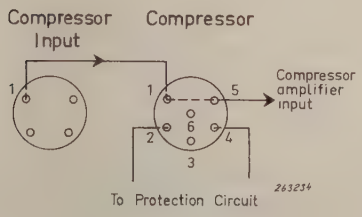


Fig. 2.2. Sine-Random Generator rear panel.

NOTE: The wiring shown in the following socket diagrams is internal.

Compressor Input:

Compressor:

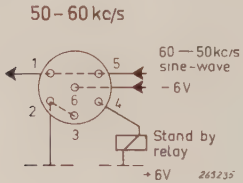


Pin 1 and 4 (3) regulation (compressor) signal input. Signal level should be between 0.5 and 1 V approx.

Pin 1 and 5. If it is desired to give the compressor circuit a particular frequency weighting, a network with the required shaping characteristic can be inserted between 1 and 5. The standard interconnection between the two pins has to be removed.

Pin 2 and 4. Intended for connection of a system protecting circuit, which switches off the shaker power amplifier if sudden changes in the feed back voltage occur.

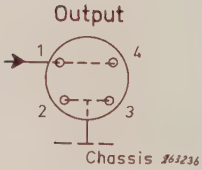
50 — 60 kc/s:



Pin 1 and 5, 2 and 3. To be utilized in a "master-slave" arrangement. Further instruction is given in part "Operation".

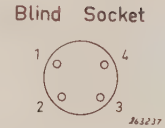
Pin 4 and 6. For remote operation of "Stand by" (refer OPERATION SWITCH on page 14). By interconnection of pin 4 and 6 the Generator is set on "Stand by".

Output:



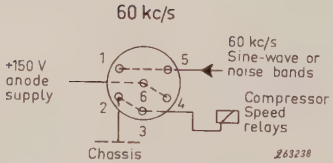
Generator output terminal. Indicating meter measures at this terminal when METER SWITCH is in position "Output Voltage".

Blind Socket:



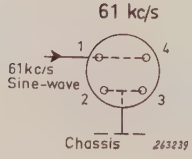
Can be used for applying auxiliary signals or special information, for example, from the scale pointer shaft. See also "Special Purpose Arrangement" below.

60 kc/s:



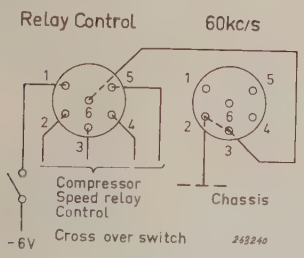
To be utilized in a "master-slave" arrangement, further instruction is given in part "Operation".

61 kc/s:



The 61 kc/s signal from the fixed oscillator is accessible on this socket.

Relay Control:

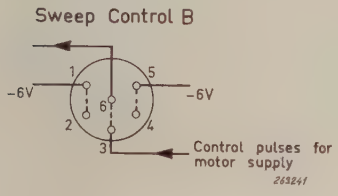


Pin 1. For governing the cross-over relay circuit in the Vibration Meter Type 2501. 6 V is present on pin 1 when the cross over switch is closed.

Pin 2, 3, 4, 5 and 6. To be utilized in a "master-slave" arrangement. Further instruction is given in part "Operation".

Pin 2, 3, and 4. Additionally used to switch in and out three stabilization networks in the Vibration Meter Type 2501.

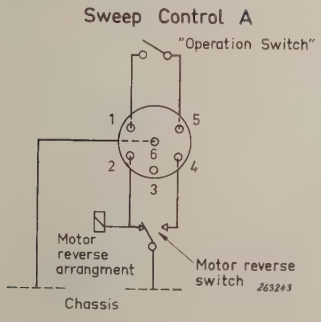
Sweep Control B:



Pin 3 and 6. Intended for remote control of motor start and stop. Further instruction is given in part "Operation". Between 3 and chassis, the control signal for the motor can be monitored.

Pin 1 and 2, 4 and 5. For remote control of a gear shift arrangement in the scanning speed system.

Sweep Control A:



Pin 1 and 5. For remote operation of the paper drive start and stop of a Brüel & Kjær Level Recorder Type 2305. When OPERATION SWITCH is set to position "Scanning On" the contact between pin 1 and 5 opens.

Pin 2, 4, and 6. For remote operation of scanning motor reverse.

NOTE. The arm of the motor reverse switch should be unscrewed during remote control.

FUSE HOLDER AND MAINS VOLTAGE SELECTOR:

Concertning the fuse see below. By the mains Voltage Selector, the Generator can be set to operate at 100, 115, 127, 150, 220 and 240 volts mains supply, 50 — 400 c/s.

ADJUSTABLE FREQUENCY RANGE BLOCKING:

Three cam discs are mounted on the frequency scale pointer shaft. These operate a pair of contacts, which in turn control the Stand-by circuit of the Generator. One cam disc which is permanently fixed on the shaft, sets the Generator to stand by when the frequency scale pointer is outside the frequency scale graduation. The two other discs are adjustable inside the frequency scale graduation, so that any initial or final part of the frequency range can be blocked, i.e. the Generator will be in stand by condition outside the preset ranges. Detailed instruction is given in "Operation".

SPECIAL PURPOSE ARRANGEMENT:

The end of the scale pointer spindle is provided with a ¼" hole. Next to the spindle will be found a mounting plate with holes. The arrangement can be used for special purpose devices which are to be governed by the angular position of the frequency scale pointer. Wiring to associated equipment can be led via the BLIND SOCKET located at the lower part of the rear panel.

FUSES:

Main Fuse 1.6 A medium lag. In circuit with the primary of the mains transformer. The fuse holder is combined with the MAINS VOLTAGE SELECTOR

at the rear of the apparatus. Two spare fuses, accessible after removing the rear plate, are placed in a holder on the upper chassis.

6 Volts D.C. Supply. 2.5 A normal. Protects the 6 V DC supply circuit. The fuse is a "soldering-in" Type. It is accessible from the rear of apparatus after the rear plate has been removed, and is located on the vertical plate to the right of the capacitor unit.

3. Operation

In the following the setting up and adjustment of vibration systems comprising the Accelerometer Preamplifier Type 2620, Vibration Meter Type 2501, and the Sine Random Generator Type 1040 are outlined. For operation of the power amplifier and the vibration exciter refer to the respective manuals.

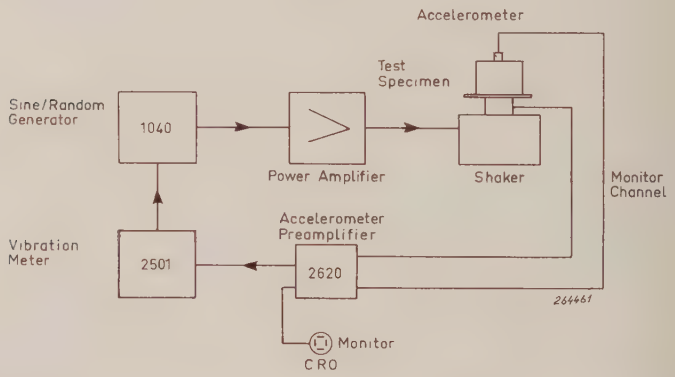


Fig. 3.1. Vibration system set-up with Accelerometer Preamplifier Type 2620, Vibration Meter Type 2501 and Sine-Random Generator Type 1040.

I. **Interconnections.**
In table 3.1 is shown how the necessary interconnections can be made.

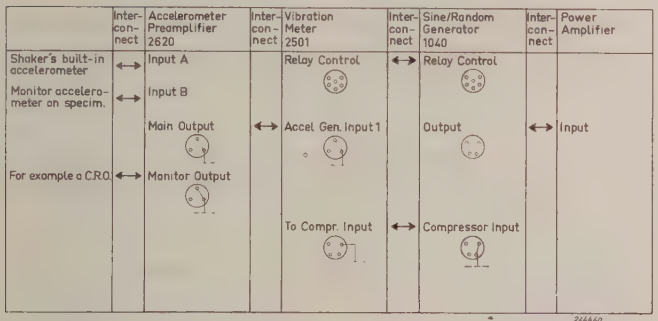
II. **Connection to Mains Supply.**
Before connecting the Preamplifier, Vibration Meter and Generator to the mains, ensure that the voltage selector, located at the rear, is adjusted to the correct supply voltage. To readjust:

1. Remove fuse by turning centerpiece of voltage selector one quarter anti-clockwise.
2. Turn by a coin the center ring of the selector so that the white mark points to te desired voltage.
3. Replace fuse.

III. **Setting of Controls.**

1. Sine-Random Generator:
   a. Turn OUTPUT VOLTAGE completely anti-clockwise, a small click should be heard.
   b. Set OPERATION SWITCH to "Scanning Off".
   c. Switch POWER to "On".
2. Vibration Meter:
   a. Switch POWER to "On".
3. Accelerometer Preamplifier:
   a. Switch POWER to "On".
   b. Set left-hand-side "Range mV/g" and Calibration Potentiometer to sensitivity mV peak per g peak of accelerometer connected to INPUT A.

Table 3.1.



   c. Set by right hand side "Range mV/g" and Calibration Potentiometer to sensitivity mV peak per g peak of accelerometer connected to INPUT B.
   d. Clamp Calibration Potentiometers in position by an Allen Key.
   e. Set LOW FREQUENCY LIMIT control to the highest acceptable figure of left hand positions.

IV. **Frequency Calibration of Sine-Random Generator.**

After the Generator POWER has been switched "On" for a few minutes, frequency calibration can be made.

1. Set control knobs as given below. Controls not mentioned can remain in any position.

METER TIME CONSTANT	to "0.3"
METER SWITCH	to "Power Freq. Beat"
FREQUENCY RANGE	to "10—10000"

OUTPUT SWITCH	to "Linear" or "High Pass"
COMPRESSOR	to "Off"
OPERATION SWITCH	to "Scanning Off"
MODE SELECTOR	to "Sine"

2. Turn FREQUENCY SCALE ADJUSTMENT until a beat shows up on the indicating meter. Fine adjust by same knob until beat ceases. In case the range covered by the control is insufficient, use also the coarse adjustment control (screwdriver operated).

   NOTE: The meter pointer swing for a slow fluctuation may be in the order of 8 dB peak to peak.

3. Thereafter set Frequency Scale pointer to 1/5 of mains frequency.
4. Fine adjust again by FREQUENCY SCALE ADJUSTMENT control to obtain zero beat.

   NOTE: The meter pointer swing for a slow fluctuation will now be in the order of 1 dB peak to peak.*)

   NOTE: As the described beat frequency is not present on the "Output" of the Generator during calibration, it is possible to frequency calibrate with the complete vibration system in operation. The compressor circuit may also be in operation but if it is, a beat can be obtained only if the voltage read on the indicating meter is igher than o.2 V with METER SWITCH in position "Oscillator Voltage".

V. **Adjustment of Automatic Frequency Scanning Range of the Sine-Random Generator.**

1. Loosen the finger screw **Sa** and **Sb** on the slotted plate Fig. 3.2.
2. Turn Frequency Scale to the lower frequency limit of the range within which it is desired to scan.
3. Set reverse-switch arm, located underneath guide slot, to its left hand position.
4. Move screw **Sa** counter-clockwise in the circular guide slot so far that the reverse switch just switches. Fasten screw **Sa** in this position.
5. Turn Frequency Scale pointer clockwise to the point of the higher frequency limit of scanning range.
6. Move screw **Sb** clockwise so far that the reverse switch just switches. Fasten screw **Sb** in this position.

---

*) Frequency calibration can also be carried out with the FREQUENCY RANGE control in position "5 — 9995". The procedure is as described above with the exception that the Frequency Scale pointer is set to mains frequency + 5 c/s, and 1/5 of mains frequency + 5 c/s respectively.

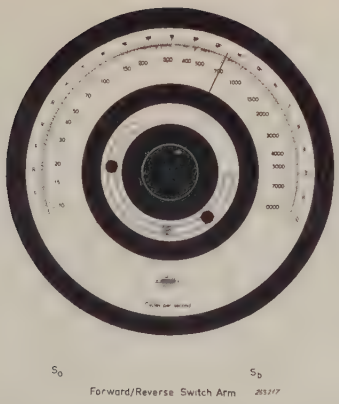


Fig. 3.2. Frequency Scale with automatic frequency scanning adjustment screws.

The selected frequency range will now be scanned automatically in a forward and reverse direction if OPERATION SWITCH is set to "Scanning On".

VI. **360° Scanning.**

Normally the automatic frequency scanning is performed as a series of forward/reverse scans and the adjustment of the scanning range is made as described under item V, p. 22. However, in some cases it may be advantageous to scan the frequency range a number of times in one direction only. This is made possible if the reverse-switch arm is removed. The arm can be easily unscrewed from the associated micro-switch by means of a screwdriver, see Fig. 3.2. If the arm is pushed to the right before it is unscrewed a continuous "forward" scanning of the frequency range is obtained, while pushing the arm to the left results in continuous reverse scanning. When used for continuous uni-directional scanning it is often necessary to partially block the upper and/or lower part of the frequency scale range. The manipulations necessary to carry out the blocking are described below.

VII. **Partial Blocking of Frequency Scale Range.**

The initial and/or the final part of the Frequency Scale can be blocked out by two adjustable cam discs. This facility can be utilized when the Frequency Scale pointer has to perform uni-directional scanning. Any initial part, 10 c/s up to 400 c/s of the scale, can be blocked, and/or any final part, 10000 c/s down to 300 c/s.

The blocking range is adjusted as follows:

1. Remove rear plate of Generator.
2. Loosen knurled lock-nut (Fig. 3.3) so much that the outer and inner cam discs can be moved in relation to the one in the middle.

   NOTE: If it is not possible to hold the Frequency Scale pointer shaft in a fixed position by holding the Frequency Scale adjustment knob (front plate) the automatic scanning can be switched on and set to lowest speed.
3. Set, for example, outer cam disc for initial Scale part blocking so that the Generator "Stand By" is released at the desired frequency. The point of release can be observed on the indicating meter when METER SWITCH is set to "Oscillator Voltage" and COMPRESSOR control to "Off". (When released the meter pointer will suddenly deflect.)
4. Set the inner cam disc for final Scale part blocking so that Generator is switched to "Stand By" at the desired frequency. (Observed by a sudden seize in meter pointer deflection).
5. Tighten the knurled lock-nut.
6. Replace rear plate.

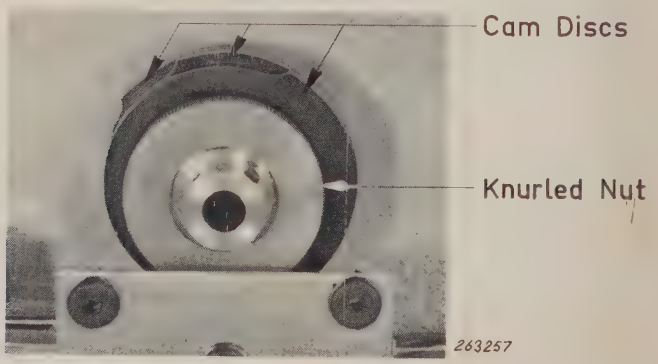


Fig. 3.3. Cam disc arrangement for blocking of Generator output signal.

VIII. **Setting of Scanning Speed.**

If a certain frequency range f_1 to f_2 and back to f_1 has to be scanned in t minutes use the procedure:

1. Determine from the Generator's Frequency Scale the number of degrees d the range f_1 to f_2 covers.
2. Find scanning speed S in degrees/min. from:

$$S = \frac{2 \times d}{t} \text{ degrees/min.}$$

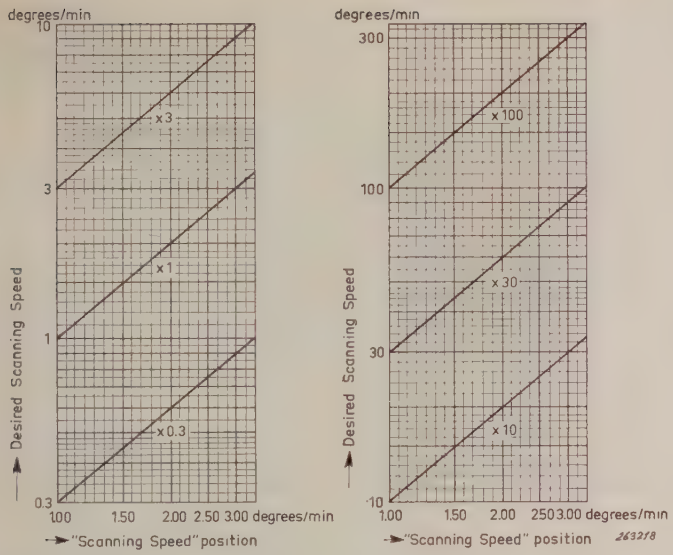


Fig. 3.4. Chart for easy determination of the "Scanning Speed Selector" and "Scanning Speed" setting.

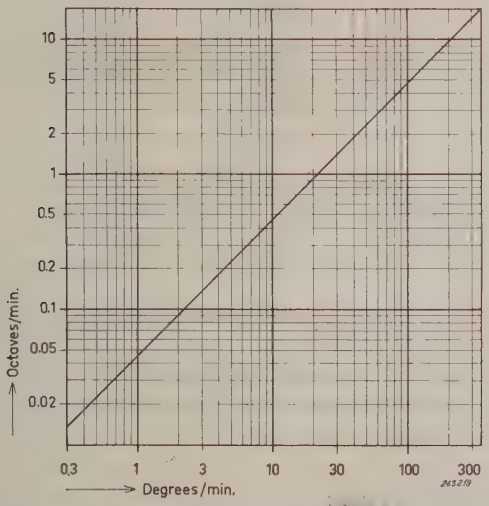


Fig. 3.5. Chart for converting scanning speed in octaves/min. to scanning in degrees/min.

3. From the curves in Fig. 3.4 can be found the position of SCANNING SPEED SELECTOR and SCANNING SPEED which give a speed nearest the calculated value S. From Fig. 3.5 is read the relationship between Octaves/min. and Degrees/min. for cases when the scanning speed is given in octaves/min.

IX. **Constant vibration level of the shaker table can be obtained for:**

A
- Velocity
- Displacement
- Acceleration
- Acceleration gradient

B
- Displacement below a preset frequency and acceleration above this frequency.
- Acceleration below a preset frequency and acceleration gradient above this frequency.

The transducer used to control the shaker table movement can be either a velocity generator or an acceleration generator. When the automatic cross-over facility of the equipment is utilized it is possible to use one type of transducer below the cross-over frequency and the other type above the cross-over. The frequency ranges covered by the various quantities and valid for the combination Accelerometer Preamplifier, Vibration Meter and Sine-Random Generator are illustrated in table 3.2. The different vibration ranges stated correspond to the ranges available on the Vibration Meter.

IX. A. **Constant Velocity (Vel.), Displacement (Displ.), Acceleration (Accel.) or Acceleration Gradient (Grad.).**

1. Set controls on Vibration Meter.
   a. FUNCTION SELECTOR to "Vel.", "Displ.", "Accel." or "Grad." as required.
   b. **Vel., Displ., or Grad. operation:**
      b.1 **DISPL. - GRAD. - VEL. INPUT** to the "Vel. Gen." or "Accel. Gen." position as required.
      b.2 **DISPL. - GRAD. - VEL. - RANGE** to required range.
      b.3 **DISPL. - GRAD. - VEL. LEVEL** fully anti-clockwise.

      Accel. operation:
      b.1 **ACCEL. INPUT** to the "Vel. Gen." or "Accel. Gen." position as required.
      b.2 **ACCEL. - ACCEL. DENSITY RANGE** to required range.
      b.3 **ACCELERATION LEVEL** fully anti-clockwise.
   c. **METER INDICATION** to the desired type of indication. The

position "R.M.S." is intended for Narrow Band Random operation, and the position "peak" (peak to peak) for sine operation.

d. **VEL. GEN. RESPONSE** to "Shaped" if an M.B. velocity pick-up Model 124 or 126 is used. Otherwise to "Flat".

e. **METER TIME CONSTANT** to a suitable value. Table 3.3 can be used as a guide.

Table 3.2.

Control of	Type of Transducer which can be used	Frequency Range
Displacement	Accelerometer	50 c/s—2000 c/s with DISPL. - GRAD. - VEL. range switch in position "0.01 in" 5*) c/s—2000 c/s for all other switch positions.
	Velocity pick-up	5*) c/s—2000 c/s for all RANGE switch positions.
Velocity	Accelerometer	50 c/s—2000 c/s with DISPL. - GRAD. - VEL. range switch in position "0.1 in/sec.". 5 c/s—2000 c/s for all other positions.
	Velocity pick-up	5 c/s—2000 for all RANGE switch positions.
Acceleration Gradient	Accelerometer	10 c/s—10000 c/s
	Velocity pick-up	10 c/s—2000 c/s
Acceleration	Accelerometer	10 c/s—10000 c/s
	Velocity pick-up	10 c/s—2000 c/s

*) 5 % down at 5 c/s.

Table 3.3.

MODE SELECTOR position	METER TIME CONSTANT
Sine	0.3 sec.
100 c/s bandwidth	3 sec.
30 c/s bandwidth	10 sec.
10 c/s bandwidth	30 sec.
3 c/s bandwidth	100 sec.

2. Set controls on Sine-Random Generator:

a. **METER TIME CONSTANT** to a suitable value. Table 3.3 can be used as a guide.

b. **METER SWITCH** to "Oscillator Voltage".

c. **OUTPUT SWITCH** to "High Pass".

d. **COMPRESSOR** to "On".

e. **COMPRESSOR SPEED** to a value which suits rate of resonance build-up during scan, and lowest sine-wave frequency or bandwidth of noise used. Owing to the risk of noise peak clipping or sine-wave distortion the "Compressor Speed" should not be set to higher values than stated in Table 3.4.

When optimum compressor speed is required throughout the frequency range of interest, use can be made of the programmed compressor speed changing. This **can only be utilized for sweeping sinewave tests** and the following remarks may be taken as a guide for its use:

When non-linear distortion in the order of 2 % is tolerable, the COMPRESSOR SPEED knob can be set to "Fast", the regulation time of the compressor is then the smallest obtainable on the Generator. If the specimen resonances exhibit high Q-values, the use of the "Fast" compressor speeds may cause instability in the regulation loop. (Instabilities show up on a monitoring oscilloscope as amplitude modulations of the sinewave test signal). Should instability occur during the sweep the setting of the COMPRESSOR SPEED knob should be changed to "Standard". The maximum non-linear distortion in the test signal then also reduces to less than 1 %.

If instabilities occur even when the COMPRESSOR SPEED is set to "Standard", the knob should be turned to "Med. Q" and if necessary to "High Q".

"Narrow Random Bandwidth" c/s	Compressor Speed dB/sec.
3	1
10	3
30	10
100	30

Table 3.4a.

"Sine" Lowest Frequency of chosen sweep range c/s	Compressor Speed dB/sec.
5	10
30	30
100	100
300	300
1000	1000
3000	3000

Table 3.4b.

Should it be impossible to obtain stable conditions with the COMPRESSOR SPEED knob in any of the afore mentioned positions, it is necessary to use one of the fixed, slow COMPRESSOR SPEED conditions.

3. **Adjust to Vibration Level:**
   a. Turn the OUTPUT VOLTAGE control of the Sine-Random Generator **slowly** clockwise and check on the **Vibration Meter** that the vibrations do not exceed the desired level.

      NOTE: Correct functioning of the regulation circuit is indicated on the Vibration Meter by the meter pointer deflection decreasing as soon as the influence of the compressor is felt and then remaining around zero.

      Adjust the OUTPUT VOLTAGE control until the meter pointer on the **Generator** deflects to approximately mid-scale.

b. **Vel. displ. or grad. operation:**

Adjust by **DISPL. - GRAD. VEL. LEVEL** control to desired level on Vibration Meter. Simultaneously readjust Generator's **OUTPUT VOLTAGE** control, if necessary, to maintain Generator indicating meter deflection within scale graduation.

Accel. operation:

Adjust by **ACCELERATION LEVEL** control to desired level on Vibration Meter. Simultaneously, readjust Generator's **OUTPUT VOLTAGE** control, if necessary, to maintain Generator indicating meter deflection within scale graduation.

c. Scan slowly through the frequency range automatically or manually, until the greatest deflection on the Generator indicating meter is found. During scan, readjust Generator's OUTPUT VOLTAGE control, if necessary, to keep reading within meter scale graduation. At the point of greatest deflection, the deflection should be nearly full scale, for example 9 V.

4. **Measurement:**

a. Start frequency range scan by setting OPERATION SWITCH of Generator to "Scanning On". Observe through one sweep that the Generator indicating meter does not exceed full scale deflection.

The scanning is stopped by setting OPERATION SWITCH to "Scanning Off".

NOTE: The shaker vibration can be cut down to 0 by turning OPERATION SWITCH to "Stand by". The position "Stand by" is included mainly to allow easy replacemen of test specimen without making it necessary to readjust the Generator: When the switch is set to "Stand by" the table vibrations cease immediately. The test specimen can now be replaced and when the new specimen is securely mounted the OPERATION SWITCH can be turned away from position "Stand by". The vibration level then increases until the predetermined test conditions are reached again.

IX. B. **Constant Displacement/Acceleration (Displ./Accel.) and Acceleration/Acceleration Gradient (Accel./Grad.).**

1. Set controls on Vibration Meter:

Displ./Accel. operation:

a. FUNCTION SELECTOR to "Auto D-A".

Accel./Grad. operation:

a. FUNCTION SELECTOR to "Auto A-G".

b. **DISPL. - GRAD. - VEL. INPUT** to the "Vel. Gen." or "Accel. Gen." position required.

c. **ACCEL. INPUT** to the "Vel. Gen." or "Accel. Gen." position required.

d. **DISPL. - GRAD. - VEL. RANGE** to required position.

e. **ACCEL. - ACC. DENSITY RANGE** to required position.

f. **DISP. - GRAD. - VEL. LEVEL** fully anti-clockwise.

g. **ACCELERATION LEVEL** fully anti-clockwise.

h. **METER INDICATION** to required type of reading.

j. **VEL. GEN. RESPONSE** to "Shaped" if an M.B. velocity pick-up Model 124 or 126 is used. Otherwise to "Flat".

k. **METER TIME CONSTANT** to a suitable value. Table 3.5 can be used as a guide.

"Mode Selector" position	"Meter Time Constant"
Sine	o.3 sec.
100 c/s bandwidth	3 sec.
30 c/s bandwidth	10 sec.
10 c/s bandwidth	30 sec.
3 c/s bandwidth	100 sec.

Table 3.5.

2. Set controls on Sine-Random Generator:

a. **METER TIME CONSTANT** to a suitable value. Table 3.5 can be used as a guide.

b. **METER SWITCH** to "Oscillator Voltage".

c. **OUTPUT SWITCH** to "High Pass".

d. **COMPRESSOR** to "On".

e. **COMPRESSOR SPEED** to a value which suits the rate of vibration resonance build-up during scan, and lowest sine-wave frequency or bandwidth of noise band used. Owing to risk of noise peak clipping or sine-wave distortion the **COMPRESSOR SPEED** shoud not be higher than stated in Table 3.4 p. 29.

3. **Adjust cross-over:**

a. Set Frequency Scale pointer to the frequency where cross-over from one type of vibration level control to the other should take place.

b. Keep frequency pointer at desired cross-over frequency by holding larger adjustment knob with one hand. Turn by other hand the small Frequency Scale knob, relative to the bigger, until cross-over just occurs. Cross-over is visible on the Vibration Meter "A.-AD." and "D.-G.-V." indicator lamps. Fine adjust by same method so that cross-over takes place exactly at the desired frequency.

4. **Adjust to Vibration Levels:**

.a Turn the OUTPUT VOLTAGE control of the Sine-Random Generator **slowly** clockwise and check on the **Vibration Meter** that the vibrations do not exceed the desired level.

NOTE: Correct functioning of the regulation circuits is indicated on the Vibration Meter by the meter pointer deflection decreasing as soon as the influence of the compressor is felt and then remaining around zero.

Adjust the OUTPUT VOLTAGE control until the meter pointer on the **Generator** deflects to approximately mid-scale.

b. Scan slowly through the frequency range (above and below the cross-over frequency) until the highest deflection on the Generator indicating meter is found. During scan, readjust Generator's OUTPUT VOLTAGE control, if necessary, to keep reading within meter scale graduation.

c. Set Frequency Scale pointer just below the cross-over frequency.

Displ./Accel. operation:

Adjust by **DISPL. - GRAD. - VEL. LEVEL** control to desired level on Vibration Meter. If necessary, readjust Generator **OUTPUT VOLTAGE** control to maintain Generator indicating meter deflection within scale graduation.

Accel./Grad. operation:

Adjust by **ACCELERATION LEVEL** control to desired level on Vibration Meter. If necessary, readjust Generator **OUTPUT VOLTAGE** control to maintain Generator indicating meter deflection within scale graduation.

d. Set Frequency Scale pointer just above the cross-over frequency.

Displ./Accel. operation:
Adjust by **ACCELERATION LEVEL** control to desired level on Vibration Meter.

Accel./Grad. operation:
Adjust by **DISPL./GRAD. - VEL. LEVEL** control to desired level on Vibration Meter.

e. Set Frequency Scale pointer to the frequency as found under item b. giving the highest Generator indicating meter deflection and readjust Generator's OUTPUT VOLTAGE control to obtain nearly full Generator meter deflection, for example 9 V.

5. **Measurement:**
   a. Start frequency range scan by setting **OPERATION SWITCH** of Generator to "Scanning On". Observe through one sweep that the Generator indicating meter does not exceed full scale deflection.

Scanning is stopped by setting **OPERATION SWITCH** to "Scanning Off".

NOTE: The shaker vibration can be cut down immediately by setting **OPERATION SWITCH** to "Stand by". In "Stand by" the red control knobs can be reset.

Master-Slave System.

1. Principle.

As explained in section 1, the outputs from all the Sine-Random Generators originate in the fixed and variable oscillator signals of the master unit. This is illustrated in Fig. 1.3., which also shows that the compressor loops are separate, though the compressor speeds are all switched by the master. Two slave units are shown but in principle there is no limit to the number used. In practice however, no more than three slaves should be connected owing to the risk of overloading the 6 V D.C. supply in the master. Also the maximum capacitive load which is applied to the fixed and variable oscillators in the master unit should be less than 2 nF.

2. Interconnections.

Wire up the individual systems as described in the foregoing text.

In addition, interconnect the sockets of the master and of the slaves as shown in Fig. 3.6.

Keep all the generator units close together. Each power amplifier must be fairly near to its associated shaker so if it is necessary to space out the shakers, the long leads should be those connecting the generators to the power amplifiers.

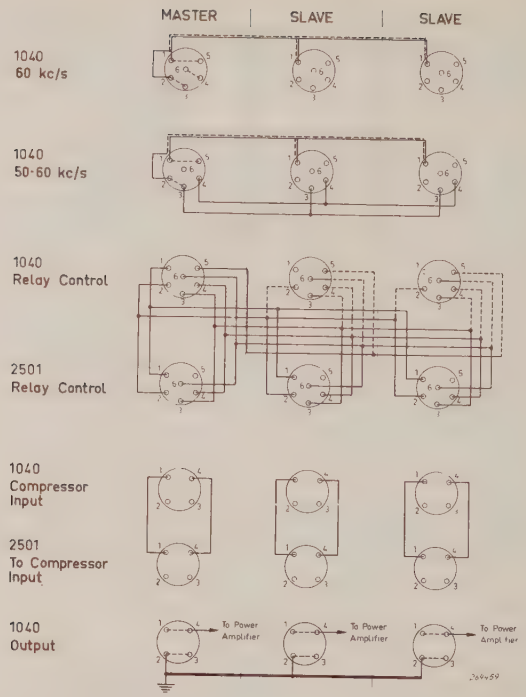


Fig. 3.6. Socket interconnections for "master slave" arrangement including three systems.

Note: Connections shown are additional to the internal connections of the individual systems.

The high frequency potentials of the various chassis may not be exactly equal, so to prevent transients due to relay switching etc. from influencing the output signals, it is advisable to connect all the earthy pins on the OUTPUT sockets together and take them to a good ground point. Use thick short wires.

It is usually advisable to directly earth the chassis of the power amplifiers. To prevent these earths forming a ground loop via the earth point mentioned above, the power amplifiers should each be fed through a transformer. Provided the transformers are located in close proximity to the power amplifier inputs, ordinary inexpensive input transformers may be used; their frequency characteristic is not important since any peculiarities are regulated out by the system.

3. Setting Up.

I. Set up the master unit as for an ordinary test. However note that if an automatically changed compressor speed programme is wanted, the choice of COMPRESSOR SPEED settings is limited to

"Standard"
"Med. Q"
or "High Q"
("Fast" should not be used)*).

If one of the fixed compressor speeds is preferred, disconnect all RELAY CONTROL plugs and short circuit the pins 3 and 6 of the terminals "60 kc/s" on the slaves, see also Fig. 3.6. (But keep interconnections for pins 1 and 6 when auto cross-over is needed).

After testing the master system alone, set OPERATION SWITCH on "Stand-by".

II. Set controls on all slaves.

OUTPUT VOLTAGE	Anticlockwise, "0"
OPERATION SWITCH	"Scanning Off"
COMPRESSOR SPEED	As used on the master
ACCELERATION LEVEL	Anticlockwise, "0"
DISPLACEMENT LEVEL	Anticlockwise, "0"
VEL. GEN. RESPONSE	As required

Frequency pointer to somewhere between 10 and 25 c/s on scale.
(Note: The pointer has to be placed within this range to avoid the compressor and stand-by relays being energized. The pointer can be locked in position by the Frequency Scanning Range stop crews). Cross-over point well above 25 c/s.

Adjusting Individual Vibrations (Level and Phase).

Turn the master's OPERATION SWITCH to "Scanning Off".

Set the vibration levels on the slave shakers, once again using the principles outlined for setting up a single system. Frequency (including cross-over) is governed by the master, but adjust each slave's OUTPUT VOLTAGE and vibration RANGE and LEVEL controls so that the vibration levels are as required — not necessarily the same for all shakers. Do **not** turn any slave's OPERATION SWITCH to "Scanning On". The desired phase relationship between the movement of the master and slave shaker tables can be adjusted on the individual master and slave. The adjustment is effected by the screwdriver operated front panel control PHASE. The shifting range is approximately 150° on each unit.

---

*) The reason is that ground loops would otherwise be formed by the various chassis earths and the relay control leads.

4. Command of the System.

Start the automatic frequency scan of the complete arrangement by setting the master's OPERATION SWITCH to "Scanning On".

The vibration levels of all shakers can be cut down practically instantaneously by switching **the master's***) OPERATION SWITCH, to "Stand-by".

To kill the vibration of one shaker only, it is necessary to turn down the relevant LEVEL and OUTPUT VOLTAGE controls. (The stand-by facility affects all shakers).

Any of the remote control facilities outlined in Chapter 4 can be applied to a complete master-slave arrangement. The connections must be made to the master unit.

*) It appears possible to stand-by the whole system with any of the OPERATION SWITCHES. However do not use this on any of the slaves because the stand-by relay circuit then becomes grounded at more than one point, thus causing hum problems (Hum about 50 dB below vibration level).

4. Operation with Level Recorder

Possibilities.

The frequency scan of the Sine-Random Generator Type 1040 can be synchronized with the paper drive of the B & K Level Recorder, Type 2305. If frequency calibrated chart paper is used in the Level Recorder, direct plots of vibration levels (to a variety*) of logarithmic and linear scales) can be obtained against frequency. This convenient presentation of information is particularly useful for

A. Monitoring the motion of the shaker table.

B. Charting the combined frequency response of the power amplifier, shaker table and specimen.

C. Recording the vibration level of some part of the specimen, i.e. to measure resonances etc.

Synchronization with Level Recorder.

Before measuring any of these vibration levels the frequency scanning system of the 1040 must be linked and synchronized with the paper drive of the Level Recorder. There are two possibilities;

either, I, the whole system can be started and stopped manually by turning the 1040's OPERATION SWITCH.

or, II, a single sweep can be initiated by pressing the SINGLE CHART button on the Level Recorder, the system then being stopped automatically after one chart has run off.

I. Manual Stop.

a) Insert roll of recording paper (QP 0123, QP 0423 or QP 1123) into Level Recorder. For details, see Instruction Manual for Type 2305.

b) On Sine-Random Generator set

SCANNING SPEED SELECTOR to one of the six right hand side positions

OPERATION SWITCH "Scanning Off"

c) Unscrew Reversing Arm (see Fig. 3.2). For clockwise scanning, leave reversing switch in right-hand positions and reduce "active" frequency range by means of camdiscs (see section 3) if required.

d) Interconnect Level Recorder's REMOTE CONTROL socket with the 1040's SWEEP CONTROL A. as illustrated in Fig. 4.1.

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*) The dynamic range of Type 2305 depends on which special potentiometer is fitted to it. A 50 dB potentiometer is delivered as standard but the following are available: 10, 25, 50 or 75 dB logarithmic; 10 to 35 or 10 to 110 linear.

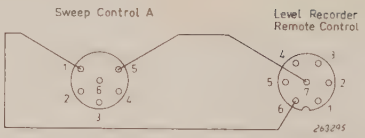

Fig. 4.1. To control the Level Recorder from the Sine-Random Generator connect the two instruments as shown here. Both sockets viewed externally.

e) On Level Recorder, set

PAPER DRIVE	"Start" and "Forward"
SINGLE CHART	In upper position
PAPER SPEED	See Table 4.1. Use the **large figures** around this knob

"Gear Lever X" (Button on right-hand end.) **Push in.**

Table 4.1.

Correlation between scanning speeds and paper speeds. The meaning of "pulse interval" will be clear from item k.

SCANNING SPEED SELECTOR position degrees/min.	0.864	2.59	8.64	25.9	86.4	259
Level Recorder PAPER SPEED mm/sec.	0.01	0.03	0.1	0.3	1	3
Pulse interval for 1040 drivemotor, millisecs.	50.00	16.67	5.000	55.54	16.66	5.554

POWER	"On"
MOTOR	"On"

f) Set frequency pointer of 1040 to frequency where scan and record should commence.

g) Adjust position of recording paper by Finger Wheel Z until pen covers frequency graduation corresponding to f).

h) Start scan and paper drive by switching 1040's OPERATION SWITCH to "Scanning On".

j) Stop at any point (less than one sweep or after several sweeps, as re-

quired by turning OPERATION SWITCH to "Scanning Off" or "Stand By".*)

k) Fine adjust 1040's scanning speed by the screwdriver operated Speed Trim control if required. (Located between the two SCANNING SPEED knobs). By trial and error it is possible to find a setting such that after a few sweeps the frequency pointer and the pen still agree. Alternatively, check, by means of an electronic counter that the 1040's sweep motor is being driven at exactly the right frequency. Connect the counter between chassis and pin 3 of SWEEP CONTROL B. Ideally the pulse

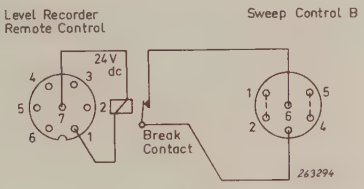

Fig. 4.2. If connected in this way, the system is started by pressing the SINGLE CHART button of the Level Recorder. Scanning stops automatically after one chart has been run off.

NOTE: Take out the interconnection (at the rear of the socket) between pins 3 and 6. The relay can, if convenient, be left coupled to the 1040 after the 7-pole plug has been removed from its socket on the Level Recorder; the 1040 is then in the same condition as when delivered.

repetition period seen here should be as given in Table 4.1. However, remember that the exact paper speed depends on the mains period and if this deviates from 20 msecs or 16.67 msecs**) the tabulated values must be adjusted accordingly.

II. Single Chart, Auto Stop.

m) Repeat items a), b) and c) above.

n) Following Fig. 4.2, connect Level Recorder's REMOTE CONTROL socket to a 24 V relay. A break contact on the relay then replaces a shorting link normally present on the back of the 1040's SWEEP CONTROL B socket. (Keep the other two shorting links, pins 1-2 and pins 4-5, in position.

*) Note: If several records are to be exactly superimposed, it is possible to run the system backwards by flicking the Reversing Switch on the 1040 to the left with a small screwdriver and moving the Level Recorder's PAPER DRIVE to "Reverse". Then stop and run forwards again. These controls must only be changed when OPERATION SWITCH is on "Scanning Off".

**) i.e. if the frequency deviates from 50 c/s or 60 c/s. (The Level Recorder gears can be arranged for operation at either 50 c/s or 60 c/s).

p) On Level Recorder, set

PAPER DRIVE	"Start" and "Forward"
SINGLE CHART	In upper position
PAPER SPEED	See Table 4.1. Use the **small figures** around this knob
Gear Lever X	**Pull out.**
POWER	"On"
MOTOR	"On". Wait for paper to stop.

q) Repeat items f) and g).

r) Turn the 1040's OPERATION SWITCH to "Scanning On". Nothing should happen.

s) Start scan and paper drive by depressing the Level Recorder's SINGLE CHART pushbutton for a few seconds, then releasing it. When the scan has stopped automatically, the 1040's frequency pointer should be in the same position as it was initially.*) If it is not, follow procedure k.

Monitoring Shaker Table Motion.

This is not always informative, since either one or two straight lines are expected if the level control is good. Nevertheless it is useful to have indisputable evidence of the test conditions. The principle is simply to run the

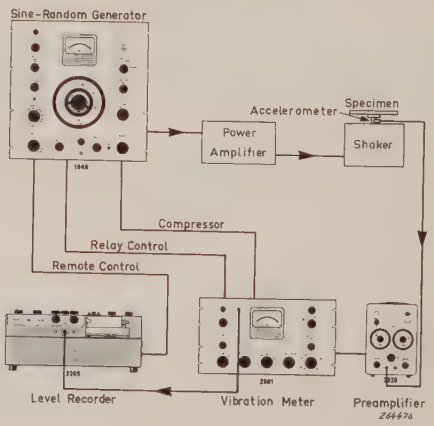

Fig. 4.3. Vibration test system coupled to a Level Recorder which plots vibration levels at the shaker table.

*) When superimposing similar recordings it may be useful to back-track the whole system. To do this, flick the Reversing Switch on the 1040 to the left with a screwdriver and move PAPER DRIVE to "Reverse". Press SINGLE CHART and wait till the paper is back at the starting point. Do not forget to return both direction controls before recording again.

test as described in Chapter 3, but to monitor and plot the vibration signal which is being used to control the shaker table.
The arrangement is as shown in Fig. 4.3.

I. Set Level Recorder's amplifying and writing system:

POTENTIOMETER RANGE	"Stand-by"
RANGE POTENTIOMETER	Insert correct one, 10 dB, 25 dB, 50 dB, 75 dB, 10/35 Lin, 10/110 Lin.
POTENTIOMETER RANGE	Set to correspond with above, viz.: "10", "25, "50", "80", "12", "16" respectively
LOWER LIMITING FREQUENCY	"10 c/s"
WRITING SPEED	"40/80"
RECTIFIER RESPONSE	"R.M.S."
INPUT ATTENUATOR	"60 dB"
INPUT POTENTIOMETER	"0"

II. Start Scan.
In manual control case by switching 1040's OPERATION SWITCH to "Scanning On".
In single chart auto stop case by pressing the Level Recorder's SINGLE CHART button.

III. Set Plotting Level.
During a trial run adjust INPUT ATTENUATOR and INPUT POTENTIOMETER so that the ordinates of the chart can be easily related to the meter scale of the Vibration Meter.

Plotting System Frequency Response.

It is sometimes interesting to chart the open loop frequency response of the system from Generator output to shaker table. There are two ways of doing this:

I. Open Loop, Measuring Table Vibration.
For safety reasons, this method is **NOT RECOMMENDED.** However, with complicated systems it can be argued that it is necessary, in which case proceed as in Fig. 4.3, but with COMPRESSOR switch of the 1040 set to "Off".

NOTE: Increase OUTPUT VOLTAGE **extremely carefully** and watch the vibration level at all frequencies of interest to see that, even at resonance, no damage is done. Away from resonance frequencies, the vibration level will be very low.

II. Closed Loop, Inverse Characteristic.

Since the closed loop system always strives to maintain constant level at the shaker table, the inverse of the required characteristic is to be seen at the OSCILLATOR jack.

Therefore it is only necessary to set up the closed loop system under proper operating conditions using the same set-up as in Fig. 4.3 but now to connect

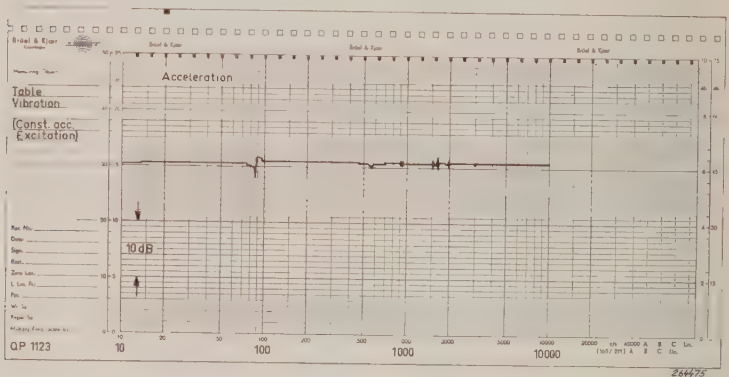

Fig. 4.4. Example of Level Recorder chart showing table vibration levels as a function of frequency. Constant acceleration control.

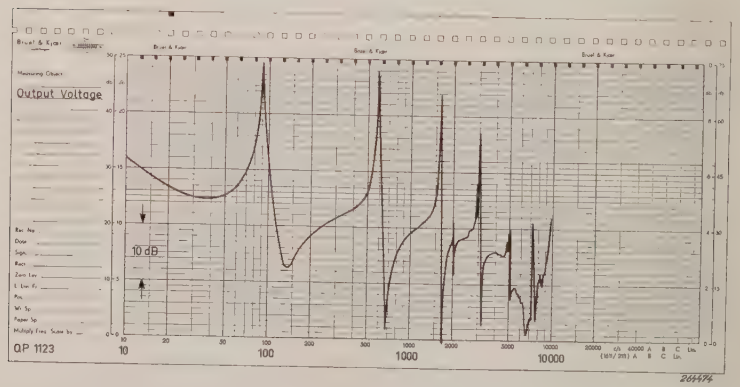

Fig. 4.5. Example of inverse characteristics of power amplifier plus shaker table. It is actually the voltage on the OUTPUT socket which is plotted here.

the OUTPUT socket*) at the back of the 1040 to the Level Recorder INPUT. A curve as that of Fig. 4.5 results.

Recording Specimen Vibration.

The intention here is to record the resonances of the specimen so a second transducer is required. The monitor channel of the Type 2620 Accelerometer Preamplifier is ideal for matching and calibrating the output from an accelerometer but the signal must then be amplified**) before being fed to

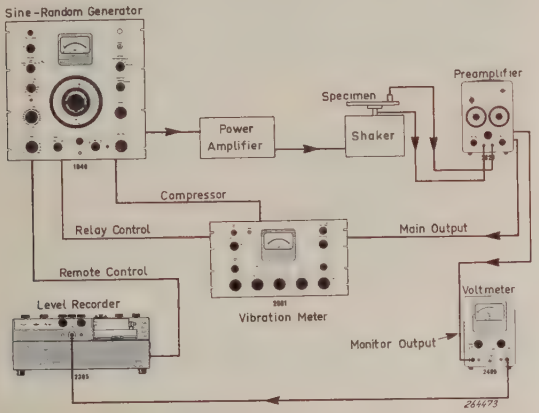

Fig. 4.6. Vibration test system in which the vibrations of the specimen are plotted on a Level Recorder.

the Level Recorder input. A Vacuum Tube Voltmeter Type 2409 forms a convenient calibrated amplifier for this purpose; see the arrangement of Fig. 4.6.

Follow the same procedure as in "Monitoring Shaker Table Motion" but this time adjust the Level Recorder's INPUT ATTENUATOR and INPUT POTENTIOMETER so that the ordinates of the chart can be easily related to the 2409 voltmeter's scale.

A typical record appears in Fig. 4.7.

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*) Not the OSCILLATOR jack on the front panel since this should not be loaded by an impedance of less than 500 kΩ.

**) If another quantity (e.g. displacement) is to be derived, an amplifier with shaping networks will be needed. One solution is to route the monitor accelerometer direct to an Accelerometer Preamplifier Type 1606, which can perform one or two integrations. Type 1606 must be powered from, for instance, a Microphone Amplifier Type 2603. The latter also takes the place of the Voltmeter Type 2409.

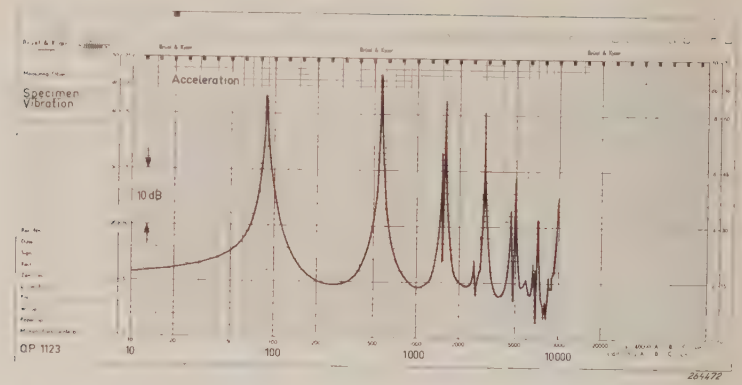


Fig. 4.7. Example of acceleration levels at the top of a specimen shaken at constant acceleration.

Recording Two Quantities Simultaneously.

Two quantities, say table vibration and specimen vibration, can be recorded "simultaneously" if the Level Recorder's Two Channel Selector is used, see Fig. 4.8.

This selector is a change over switch which is actuated from the recorder's Drive Shaft II. Set this up as described in the Level Recorder manual, using a 180° cam disc (OD 0059).

Choose a position of Drive SHAFT SPEED R.P.M. such that the pen has time to take up position relative first to one signal and then to the other, still maintaining resolution.

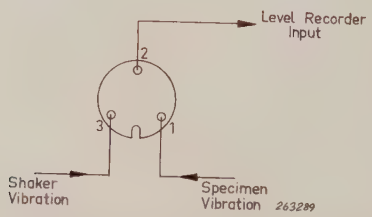


Fig. 4.8. Method of connecting the Two Channel Selector on the Level Recorder.

5. Remote Control Facilities

Start and Stop of Automatic Frequency Scan.

Connect a switch or pushbutton to the socket SWEEP CONTROL B as shown in Fig. 5.1.

NOTE: Remove interconnection (placed on rear of socket) between 3 and 6. When the switch is opened the frequency scan stops immediately.*)

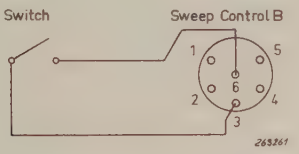


Fig. 5.1. Connection of an external switch for remote start and stop of the automatic frequency scan.

Forward and Reverse Frequency Scan.

1. Unscrew reverse-switch arm located in the Generator Frequency Scale guide plate. (See Fig. 3.2).

> **Warning.** If the reverse-switch arm is not removed the scanning drive will be damaged as the scanning is not reversed when the finger screw for the high frequency scan limit setting reaches the arm.

2. Set reverse-switch arm in backwards scan position i.e. to its left hand position.
3. Connect a pushbutton to the SWEEP CONTROL A socket as illustrated in Fig. 5.2.

*) When employing the Brüel & Kjær Level Recorder Type 2305 in the vibration system start and stop of its paper drive can also be remotely controlled.

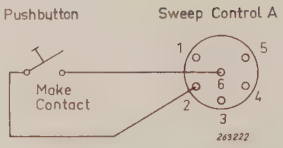


Fig. 5.2. Connection of an external push-button for reversing remotely the direction of the frequency scan.

4. Set OPERATION SWITCH to "Scanning On" position.
When operating the pushbutton i.e. closing the contact, the frequency scan will run forwards.

Stand by.

The stand by facility can be remotely controlled when a switch or pushbutton is connected to the socket 50—60 kc/s as shown in Fig. 5.3. By closing the contact the Generator is set to stand by.

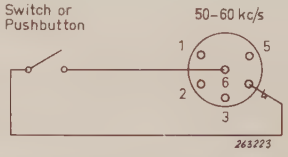


Fig. 5.3. Switch connection for remote control of the "stand by" function.

6. Specification

OSCILLATOR SECTION

Three types of output are available from the oscillator:

1. Narrow Bands of Random Noise
2. Sine-waves
3. Wide Band Random Noise.

1. **Narrow Bands of Random Noise.**
   A narrow band of random noise can be swept automatically throughout the frequency range 10 to 10ooo c/s (or 5—9.995 c/s) with a constancy of power better than ± 1 dB.
   a. **Bandwidths.** Four different bandwidths can be selected. The "shape" of the noise bands are tabulated below:
   Attenuation vs. Frequency Characteristics of the Noise Bands.

Frequency	B = 3 c/s	B = 10 c/s	B = 30 c/s	B = 100 c/s
$f_0 \pm B$*	> 10 dB	> 20 dB	> 20 dB	> 20 dB
$f_0 \pm 2\,B$*	> 20 dB	> 40 dB	> 40 dB	> 50 dB
$f_0 \pm 3\,B$*	> 30 dB	> 50 dB	> 50 dB	> 60 dB

   b. **Voltage Distribution.** Symmetrical Gaussian (normal) instantaneous voltage distribution up to four times the r.m.s. value (4 σ) at full output voltage.
   c. **Output:** Maximum r.m.s. output voltage is 10 V. Load impedance should be greater than 10 kΩ//3 nF. Harmonic distortion is less than o.5 %. The signal to extraneous noise ratio is better than 60 dB at maximum output.
   d. **Frequency Scale:** 10—10ooo c/s truly logarithmic. Accuracy 1 % ± o.5 c/s.

2. **Sine-waves.**
   Continuously tuneable within the frequency range 10 to 10ooo c/s (or 5—9,995 c/s). Amplitude accuracy better than ± o.5 dB.

*) B = 3 dB noise bandwidth. The spectrum density within the bandwidth, B, is uniform to within ± 1.5 dB.

a. **Output:** Maximum 10 V. (r.m.s.). Load impedance should be greater than 10 kΩ//3 nF. Harmonic distortion is less than o.5 %. The signal to noise ratio is better than 60 dB at maximum output.
b. **Frequency Scale:** 10—10ooo c/s truly logarithmic. Accuracy 1 % ± o.5 c/s.

3. **Wide Band Random Noise.**
a. **Frequency Spectrum:** Flat to within ± 1 dB in the range 5—10ooo c/s.
b. **Output Voltage:** 10 V r.m.s. (8 mV^2/cps. approx.).
c. **Voltage Distribution:** Symmetrical Gaussian (normal) voltage distribution up to four times the r.m.s. value (4 σ) at full output voltage.

COMPRESSOR SECTION

a. **Frequency Range:** Flat to within ± o.5 dB from 5 to 10ooo c/s.
b. **Dynamic Range:** 45 dB (40 dB is compressed to less than 1.5 dB). Required input signal for full regulation is 1 V r.m.s. approx.
c. **Signal Rectifier:** Average absolute type, with interchangeable integration times (regulation speeds).
d. **Regulation Speed:** o.3 — 1 — 3 — 10 — 30 — 100 — 300 — 1ooo and 3ooo dB/sec. Selectable by means of a switch, or automatically programmed.

METER SECTION

a. **Signal Rectifier:** Quasi — r.m.s.
b. **Integration Times:** Six meter time constants selectable o.3, 1, 3, 10, 30, and 100 sec. (For definition of the time constants vide "Control Knobs, Terminals etc.").
c. **Meter Scale:** Semi-logarithmic voltage scale 0—10 V. Semi-linear dB scale 0—20 dB. Scales are mirrored.
d. **Indicating Meter:** Moving coil instrument fully protected against electrical overload.

MISCELLANEOUS

a. **Automatic Frequency Scanning:** A built-in frequency sweep unit allows automatic scanning of any predetermined part of the frequency range (or full 360° rotation of the frequency scale pointer) at 72 different scanning speeds. The transistor power supply used to control the sweep motor allows synchronization between the oscillator frequency sweep and external recording devices*). Scanning speed range: o.3 degrees/min to 335 degrees/min. Fully reversible scan.
b. **Frequency Limit Controls:** Front-panel set screw adjustment, or partial blocking by means of built-in cam-discs.

*) E.g. the Brüel & Kjær Level Recorder Type 2305.

c. **Automatic Cross-over Control:** Automatic Cross-over at any frequency between 15 c/s and 1ooo c/s. Type of cross-over can be remotely controlled from the Vibration Meter Type 2501.

d. **Remote Control:** Start-Stop of automatic frequency scan. Foreward-reverse changing of frequency scan.

e. **Stand-by:** When Generator is set to stand-by the output voltage is suppressed by more than 70 dB in relation to full output voltage.
Decay Time: 150 m. sec approx. (90 %—10 %).
Rise Time: Without compressor working: 30 m. sec. approx. (10%—90 %). With compressor working: Dependent on compressor speed setting.

f. **Master-Slave Arrangement:** Special parallel operation of two or more Generators.

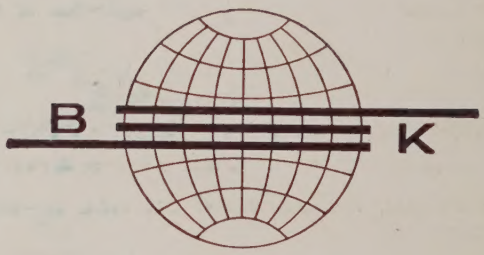
GENERAL

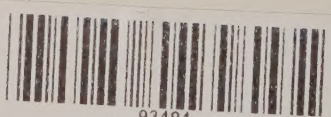
Overall Stability: Operates within stated tolerances for a voltage deviation of up to ± 10 %. Operable up to ± 15 % mains voltage deviation.

Power Supply: 100, 115, 127, 150, 220 or 240 volts, 50—400 c/s. Power consumption: 120 W.

Dimensions:
Type 1040B. Mahogany cabinet. Width: 51 cm, height: 52 cm, depth: 34 cm.
Type 1040C. For 19″ rack mounting.

Weight: 38 lbs. (17 kg).

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